F[illegible]ovation

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

[illegible] undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of [illegible]eregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the [illegible]ptroller-General, hereby certify that annexed hereto is a true copy of the documents as [illegible]ally filed in connection with the patent application identified therein.

[illegible] certify that the attached copy of the request for grant of a Patent (Form 1/77) bears an [illegible]ment, effected by this office, following a request by the applicant and agreed to by the [illegible]roller-General.

I[illegible]dance with the Patents (Companies Re-registration) Rules 1982, if a company named in t[illegible]ificate and any accompanying documents has re-registered under the Companies Act 1[illegible]h the same name as that with which it was registered immediately before re-registration s[illegible]he substitution as, or inclusion as, the last part of the name of the words "public limited c[illegible]" or their equivalents in Welsh, references to the name of the company in this certificate an[illegible]ccompanying documents shall be treated as references to the name with which it is so re-[illegible]ed.

In a[illegible]ce with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L[illegible]LC.

Re-r[illegible]on under the Companies Act does not constitute a new legal entity but merely subje[illegible]ompany to certain additional company law rules.

Signed [signature]

Dated 17 May 2006

BEST AVAILABLE COPY

Patents Form 1/77

( nts Act 1977
(Rule 16)

The Patent Office

THE PATENT OFFICE
29 DEC 2000
RECEIVED BY HAND

1/77

# Request for grant of a patent

*(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form.)*

The Patent Office

Cardiff Road
Newport
Gwent NP9 1RH

Fee: £0

| | | |
|---|---|---|
| 1. | Your reference | 42708/IML |
| 2. | Patent application number *(The Patent Office will fill in this part)* | **0031817.0** ~~31DEC00 E594742-3 D01631~~ P01/7700 0.00-0031817.0 29 DEC 2000 |
| 3. | Full name, address and postcode of the or of each applicant *(underline all surnames)* | VTECH COMMUNICATIONS, LTD.<br>23/F., Tai Ping Industrial Centre<br>Block 1, 57 Ting Kok Road<br>Tai Po, N.T., Honk Kong |
| | Patents ADP number *(if you know it)* 07435001001 | |
| | If the applicant is a corporate body, give the country/state of incorporation | Hong Kong |
| 4. | Title of the invention | Digital Radio Frame Structure for a Cordless Telephone |
| 5. | Full name, address and postcode in the United Kingdom to which all correspondence relating to this form and translation should be sent | ~~Reddie & Grose<br>16 Theobalds Road<br>LONDON<br>WC1X 8PL~~<br>HASELTINE LAKE<br>120 REDCLIFF STREET<br>BRISTOL<br>BS1 6HU |
| | Patents ADP number *(if you know it)* | ~~91001~~ SEE 51/77 17/5/06 |
| 6. | If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number | Country / Priority application *(If you know it)* / Date of filing *(day/month/year)* |
| 7. | If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application | Number of earlier application / Date of filing *(day/month/year)* |
| 8. | Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*<br>*a) any applicant named in part 3 is not an inventor, or*<br>*b) there is an inventor who is not named as an applicant, or*<br>*c) any named applicant is a corporate body.*<br>*See note (d))* | YES |

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document.

| | |
|---|---|
| Continuation sheets of this form | |
| Description | 18 |
| Claim *(s)* | |
| Abstract | |
| Drawing *(s)* | 5 |

10. If you are also filing any of the following, state how many against each item.

| | |
|---|---|
| Priority documents | |
| Translations of priority documents | |
| Statement of inventorship and right to grant of a patent *(Patents Form 7/77)* | |
| Request for preliminary examination and search *(Patents Form 9/77)* | |
| Request for substantive examination *(Patents Form 10/77)* | |
| Any other documents *(please specify)* | |

11. I/We request the grant of a patent on the basis of this application.

Signature [signature] Date 28 December 2000

12. Name and daytime telephone number of person to contact in the United Kingdom

I M LOVELESS
020-7242 0901

*Warning*
*After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or such direction has been revoked.*

*Notes*
a) *If you need help to fill in this form or you have any questions, please contact the Patent Office on 0645 500505.*
b) *Write your answers in capital letters using black ink or you may type them.*
c) *If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.*
d) *If you have answered 'Yes' Patents Form 7/77 will need to be filed.*
e) *Once you have filled in the form you must remember to sign and date it.*
f) *For details of the fee and ways to pay please contact the Patent Office.*

TITLE OF THE INVENTION

Digital Radio Frame Structure for a Cordless Telephone

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates in general to wireless digital communications. In particular, the invention relates to a data frame structure for use in a wireless communications system which provides improved communications performance under interference conditions.

2. Background Art

The issue is involved with the definition of an efficient digital radio protocol for use with cordless telephones operating in the US 902 to 928 MHz ISM band, as regulated by FCC Part 15 rules. This frequency band is occupied by many different types of radio system and as such the optimum protocol must comply with a number of potentially conflicting requirements as follows.

1. Compliance with the radio emission output power , spurious limits and occupied bandwidth rules as specified in FCC Part 15.
2. Be robust to the presence of other non-co-operative radio systems also using this radio band.
3. Maximise range of operation by transmitting the maximum allowable power within the minimum practical noise bandwidth.
4. Maximise audio quality through the use of high quality digital audio coding schemes.
5. Be capable of supporting simultaneous, multiplexed control and audio information.

6. Minimise implementation complexity and therefore cost to allow the system to be utilised in mass volume consumer electronic applications such as cordless telephones.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1: TDD Frame Structure

Figure 2: Table of Radio Protocol digital multiplex formats

Figure 3: D MUX Format with Frequency Diversity

Figure 4: D MUX Format without Frequency Diversity

Figure 5: VMUX Format with Frequency Diversity (B&D Data)

Figure 6: VMUX Format without Frequency Diversity (B&D Data)

Figure 7: VMUX B Channel Check Field Calculation (B & D channel)

Figure 8: Inverted Bits in B Channel Sub-frame

Figure 9: VMUX Format with Frequency Diversity (B Channel only)

Figure 10: VMUX Format without Frequency Diversity (B Channel only)

Figure 11: VMUX B Channel Check Field Calculation (B channel only)

Figure 12 : AMUX Format

BEST AVAILABLE COPY

DETAILED DESCRIPTION OF THE INVENTION

While this invention is susceptible to embodiment in many different forms, there are shown in the drawings and will be described in detail herein specific embodiments. The present disclosure is to be considered as an exemplification of the principle of the invention intended merely to explain and illustrate the invention, and is not intended to limit the invention in any way to embodiments illustrated.

The base and handsets, which comprise the two key units in a cordless telephone, communicate using frequency hopping spread spectrum. Time division duplexing (TDD) is employed between the base and handset to allow full duplex communications. The capability for two slot Time Division Multiple Access is provided to allow frequency diversity for protection against very fast bursts of radio interference. This is achieved by repeated audio data transmission on successive carrier hops on widely spaced frequencies. Alternatively these two time slots could be used to support simultaneous two handset operation. Finally, a dedicated time slot is provided for RSSI (Receive Signal Strength Indication) scanning of all available channels. This last feature enables adaptive channel replacement to improve link performance during frequency hopping.

The base and handset hop using a psuedo random group of at least 53 RF channels, referred to as the hop pattern. The RF channels making up the hop pattern are selected from a pool of 102 available channels, and are arranged in a pseudo random pattern. When an active link is not established, the base and handset communicate using a common hop pattern, referred to as pattern 0. The pseudo random seed for pattern 0 will be derived from each products unique security ID to

further minimize potential interference between cordless phones which use the same protocol.

Once an active link is established, the base transceiver and handset activate an adaptive channel replacement algorithm. This continuously replaces known bad channels with known good channels, updated approximately once every second.

Therefore, four measures have been taken to improve the tolerance of the proposed radio protocol to interference:

- Frequency Hopping
- Channel Replacement
- Frequency Diversity
- Increased voice data parity checking

The basestation does not transmit continuously. All links are initiated under the control of the basestation. The handset can request a link using the AMUX channel. Further details on the radio parameters and digital protocol multiplexes are described in the following sections.

## 1.1 Radio Frequency Interface

### 1.1.1 FCC Compliance

The proposed radio protocol will meet the FCC part 15 requirements for a frequency hopping system operating in the 902 to 928 MHz ISM band.

### 1.1.2 RF Channels

There will be 102 RF channels available, each spaced approximately 256 kHz apart. A communication link will use 53 of the available channels.

### 1.1.3 Modulation and Data Rate

The modulation will be 2-level Gaussian Minimum Shift Keying (GMSK) with BT=0.5. A binary 1 is the higher transmit frequency and a binary 0 is the lower transmit frequency. The modulating data will be shaped using a Gaussian filter with a BT=0.5 in order to reduce modulation sidebands.

The gross data rate will be 170.666 kbps (32.768 MHz/192) (approximated to 171 kbaud). The -20 dB bandwidth of each modulated carrier will be 170 kHz (+/- 85 kHz).

### 1.1.4 Frequency Hopping Overview

At the start of a frame, the base and handset hop to the same RF channel. There is a guard band to allow the radio receiver hardware to settle. The base then transmits either one or two data packets to the handset at 171 kbaud depending on whether frequency diversity is in operation. There is a second guard band to allow for Transmit/Receive (T/R) switch and propagation delays after which the handset transmits either one or two data packets back to the base station on the same RF frequency, again depending on whether frequency diversity is in operation. At the end of each frame both the base and handset perform a RSSI scan lasting approximately 300 usec. The base and handset then hop to the next RF frequency in the channel hopping pattern. The frame rate is 100 Hz. The frame frame length is equivalent to 1707 data bits.

### 1.1.5 Frequency Hopping Pattern

Each of the 102 RF channels is assigned a channel number between 0 and 101. A group of 53 channel numbers make up the hop pattern. The channel numbers in the hop pattern are chosen so that it appears random and that a channel number does not repeat in the pattern.

In order to ensure that the channels in the hop pattern are not prone to errors, an adaptive channel allocation procedure is used to substitute known good channels for known bad channels. This procedure operates on the basis of the RSSI channel scan performed at the end of each 10 msec frame along with recorded digital bit errors detected in the received data streams.

## 1.2 Digital Radio Protocol

### 1.2.1 TDD Frame Structure

A Time Division Duplexing (TDD) format is used to exchange data between the base and handset. The TDD frame structure is illustrated below in Figure 1. Each TDD frame lasts for 1707 transmit symbol periods which is very close to 10ms. The TDD frames are aligned with the channel hopping so that the start of each frame corresponds to the start of a RF channel change.

At the start of the TDD frame, there is a 69 bit time (405µs) guard band to allow the RF PLL to settle to the new frequency for this 10 msec frame. The base then transmits a 777 or 411 bit packet of data to the handset at 171 kbaud. The handset adjusts its timing so that the first data bit arrives 69 bits after the start of its TDD frame.

After receiving the packet, the handset inserts a 34 bit guard band (200 usec), to allow the hardware to settle from switching between transmit and receive. The handset then transmits a 777 or 411 bit packet back to the base station. At the base, the guard band between transmit data and receive data fluctuates in duration due to varying propagation delay between the base and the handset.

At the end of each frame both the handset and the basestation measure the RSSI level on each of the 74 available channels at the rate of one measurement per frame. A total of 50 bits (292 usec) is allocated for this task. This allows the Radio Transceiver to switch to a new frequency and settle with sufficient stability (200 usec) to allow a RSSI measurement to be made (integrated over 100 usec). The measurement is made using an Analog to Digital Converter (ADC) in the controlling baseband processor for the cordless telephone.

The base must adjust its receive timing in order that each data packet is acquired correctly. However an additional guard band is not required since the PLL settle period of 69 bits (400usec) at the start of the frame structure is ample.

The frame structure also allows for frequency diversity: data can be transmitted twice in successive frames. The benefit of this is an enhanced tolerance to interference. Frame structures are defined with and without the frequency diversity. In the latter case, the second data slots indicated in Figure 1 are not used and the data is transmitted only once in the first slot.

While the illustrated embodiment utilizes the first TX field to transmit subpacket (n-1), with the second field transmitting subpacket (n), in other embodiments it may be desirable to reverse the order. The transmission of subpacket (n-1) first is beneficial in

that both copies of subpacket (n-1) are therefore received before a single subpacket (n) is received; the error-free subpacket (n-1) (if any) can be selected from amongst both transmissions, and processed, before subpacket (n) arrives. Therefore, buffer memory requirements and processing overhead are reduced, in that multiple subpackets need not be stored and processed simultaneously.

However, in other embodiments it may be desirable to transmit the new subpacket (n) before the redundant transmission of subpacket (n-1) to allow for the implementation of increased power savings. This is because when a subpacket is received without error during its first transmission, the receiver can be powered down during the time period of the subsequent redundant transmission. For example, if the receiver has already correctly received subpacket (n-1) in the previous frame, the receiver can be powered down after synchronizing during the the RXsync field, and receiving subpacket (n). If subpacket (n-1) is sent before subpacket (n), then the receiver cannot be powered down during the redundant receipt of subpacket (n-1) because it must subsequently be ready for receipt of subpacket (n).

Whether or not frequency diversity is used is under software control of the cordless telephone's processor.

### 1.2.2 Multiplexer Format

There are three different sub-channels of data that have to be multiplexed within the available data bandwidth. There is the Synchronization (Syn) channel, Audio (B) channel and Data (D) channel. The Syn channel is used to establish bit and TDD frame synchronization, the B channel carries audio data and the D channel carries

MCU data. Three distinct packet structures, referred to as multiplexes, are utilized depending on the system's mode of operation. These are DMUX, VMUX, and AMUX. Each multiplex allocates different amount of bandwidth to the various sub-channels.

The DMUX format carries the synchronization channel and data channel. This is used for frame synchronization and in cases where high control data rates are needed in the absence of voice data.

The VMUX channel is principally intended for B channel digital voice data. It always contains the synchronization channel and the B channel. It is also able to carry D channel data at a low effective bit rate. If no D channel data is presented by the processor to the radio interface, the spare bits are automatically used for additional voice data parity checking.

The AMUX format is used only by the handset to indicate to the basestation that a link is required. It is optimized to allow rapid synchronization by the receiver, and it caries no information apart from the basestation ID code.

When frequency diversity is being used, each packet of data is sent twice. The first time that each packet is sent is termed "Dataset 1" while the second time is termed "Dataset 2".

The muliplex format type is coded into 6 bits which follow the synchronization datastream. If the first two bits are '00', this indicates that frequency diversity is not in operation and the following 2 bits indicate the MUX type. If the first two bits are not '00', frequency diversity is in operation and the first 2 bits represent the MUX format for the second data packet. Bits 3 and 4 then indicate the MUX format for the first data packet.

The last 2 bits of the format word are parity bits generated from the first two pairs of the bitstream. The coding is defined in Figure 2.

All formats contain the Synchronization channel. The control software controls which format is used. It does this by writing various flags to a control register which selects between the following conditions:

- AMUX / DMUX / VMUX
- Frequency diversity on/off

If a parity error is detected on the MUX_ID word no data will be decoded from the associated packet.

Note that one novel feature concerns the automatic transition between VMUX (B&D data transmission) and VMUX (B data only) modes if there is no D data present in the associated transmit buffers. This then allows increased error detection, in the form of parity bits, to be added when transmitting only digital audio data using the B channel.

### 1.2.3 DMUX Format

The DMUX is used in two situations: First, it is used to establish bit and frame synchronization using the SYN channel. Second, it has the highest D channel data rate and is used whenever data must be exchanged quickly. For DMUX, the D channel data rate is 36kbps and the effective data rate is 20kbps.

DMUX is distinguished from the other formats by the first six bits after the Sync marker, known as MUX_ID. Only the SYN channel and D channel are present. The SYN channel consists of a preamble and a synchronization marker. The preamble is a

15 bit 1/0 pattern beginning with a logic 1. The synchronization channel marker is 24 bit long which is SYNCF (hex A0D8D7) for the base and SYNCP (hex 5F2728) for the handset.

The MSB of the synchronization marker is sent first. The D channel consists of 5 packets, each of 72 bits of signaling data. The DMUX format with frequency diversity is shown in Figure 3. The DMUX format without frequency diversity is shown in Figure 4.

The areas in the frame marked as 'not used' in Figure 4 do not carry information. During these times, both the transmit and receive paths in the radio turned off to reduce power consumption in the cordless telephone.

### 1.2.4 VMUX Format

The basic VMUX format contains both B channel and D channel data, as shown in Figure 5. It is used to transport audio and control data across the link. The VMUX format allocates most of its bandwidth to B channel voice data, while providing for a nominal level of D channel bandwidth. Thus, data messaging can occur during transmission of voice data, such that the voice stream need not be interrupted by switching to a data packet format to accomplish any necessary data messaging, such as adaptive frequency allocation.

The VMUX has the full 39 bits of preamble (15 bits) and synchronization (24 bits) data. The synchronization channel marker is 24 bit long which is SYNCF (hex A0D8D7) for the base and SYNCP (hex 5F2728) for the handset.

Following the preamble and synchronization words, 6 bits are used to identify the type of channel. The data structure up to and including these bits is common for all channel types. The VMUX format for B and D channel data with frequency diversity is shown in Figure 5.

After the channel identifier bits either one or two packets of mixed B-channel and D-channel are transmitted. If frequency diversity is not being used only one packet is transmitted, otherwise two packets are transmitted. The VMUX format for B and D channel data without frequency diversity is shown in Figure 6.

The data packets are divided into 10 sub-frames, each one consisting of 8 4 bit digital ADPCM encoded words, three bits of DMUX data and a check bit. The check bit is calculated to be the even parity of the 2 MSB of the 8 ADPCM words, as shown in Figure 7.

The 3 data bits form part of a standard DMUX packet which consists of a total of 72 bits. The final 6 bits in the DMUX frame bring the total number of DMUX bits per frame up to 36. Thus a complete DMUX packet is transmitted every 2 frames. Prior to transmission, the 10 parity bits in each VMUX packet are scrambled by modular two adding the bits with the basestation ID. At the receiver, the parity bits are descrambled before being checked.

To ensure that there are sufficient data transitions, every second bit, beginning with the second bit, in each B-channel sub-frame is inverted for transmission, as shown in Figure 8. The bits are again inverted at the receiver.

Prior to transmission, the parity bits in each VMUX packet are scrambled by modular two adding the bits with the LSB of the basestation ID. At the receiver, the parity bits are descrambled before being checked.

On reception, the incoming parity bits are compared with parity bits generated from the incoming B channel data. If any parity bit does not agree then the complete 32 bits of data (8 ADPCM samples) is flagged as bad.

The total D channel data rate is 3.6kbps and the effective data rate is 2.0kbps. The total B channel data rate is 33kbps and the effective data rate is 32kbps. In the event that there is no D channel data in the buffer for transmission, the radio interface hardware automatically uses the spare bits for an increased parity check on the voice data. The MUX_ID bits are set to either '100' or '101' to indicate this.

The VMUX format with no D channel data but with frequency diversity is shown in Figure 9. The VMUX format with no D channel data and without frequency diversity is shown in Figure 10.

As before, the data packets are divided into 10 sub-frames, each one consisting of 8 ADPCM words, but now there are 4 parity bits. The parity bits are calculated to be the even parity of the 2 MSB of pairs of the 8 ADPCM words, as shown in Figure 11.

Six additional data bits are required at the end of the VMUX field to make the total bit length compatible with the other data formats. These are set to be alternating '1' and '0' generated by toggling the final bit in the preceeding word. No use is made of these bits on decode.

Prior to transmission, the parity bits in each VMUX packet are scrambled by modular two adding the bits with the LSB of the basestation ID. All 4 parity bits in a

given field are scrambled with the same ID bit. At the receiver, the parity bits are descrambled before being checked.

On reception, the incoming parity bits are compared with parity bits generated from the incoming B channel data. If any of the 4 parity bits do not agree then the complete 32 bits of data (8 ADPCM samples) is flagged as bad.

The total data B channel rate in this configuration is 36kbps and the effective data rate is 32kbps.

### 1.2.5 AMUX Format

AMUX is used by the handset to request a link. The handset and basestation frames may be out of phase due to clock drift while the system is in Standby mode. Therefore when the handset comes out of standby (once every second) it enters acquire mode with a deliberate frame phase offset to ensure that the synchronization bit transmitted by the basestation falls within the handset receive window. By implementing a specific multiplex format for this task, synchronization can be attained more rapidly and reliably.

To ensure that the handset can request a link, it must be able to transmit a detectable pattern throughout the complete length of it's transmit slot. This is the AMUX format. The only data transmitted in this format is the Basestation ID code.

The AMUX structure is illustrated in Figure 12. It consists at a high level of 11 repeated copies of a synchronization code packed to form a standard length frame.

Each repeat contains the standard preamble, synchronization field and mux identifier bits contained in the other formats. This is followed by the basestation ID code and some packing bits.

The total number of bits in the AMUX format is 777 and the duration of the AMUX packet is 4544usec. Each repeated packet in the sequence contains 62 bits and lasts 362us.

The AMUX is transmitted only by the handset and is for obtaining the base's attention.

## 2 Compliance of Proposed System with Requirements

The proposed radio protocol described in Section 2 meets the design objectives as described in the introduction as follows.

1. **Objective** : Compliance with the radio emission output power , spurious limits and occupied bandwidth rules as specified in FCC Part 15.

The choice of the GMSK modulation type, frequency hopping protocol and radio emission complies with FCC Part 15.

2. **Objective** : Be robust to the presence of other non-co-operative radio systems also using this radio band.

The proposed protocol supports the use of frequency hopping, adaptive frequency hopping and frequency diversity. Specifically, the inclusion of an independent RSSI

slot in the frame structure described in Figure 1 allows the radio receiver to 'look ahead' and build up tables of radio channels which are good (no interference present) and bad. These RSSI tables can then be used during the frequency hop pattern adpation process.

3. **Objective :** Maximise range of operation by transmitting the maximum allowable power within the minimum practical noise bandwidth.

   The proposed protocol reduces the required receiver bandwidth to170 kHz, compatible with the needs of achieving long range (300m in Line of Sight conditions) with acceptably low output power (+12 dBm).

4. **Objective :** Maximise audio quality through the use of high quality digital audio schemes.

   The proposed proctol supports the use of 32 kbps ADPCM (ITU G.726 standard) digital voice encoding to support toll quality audio over cordless telephone transmission.

5. **Objective :** Be capable of supporting simultaneous and multiplexed control and audio information.

   The DMUX digital data format allow error protected control data to be transmitted

between handset and base at data rates up to 20 kbps. The VMUX digital data format allows the combined transmission of 2 kbps error protected control data and 32 kbps digital audio data.

6. **Objective :** Minimise implementation complexity and therefore cost to allow the system to be utilsed in mass volume consumer electronic applications such as cordless telephones.

The use of TDD removes the need for expensive radio frequency filters to support transmit and receive channels for full duplex communications between handset and basestation. The frequency hop times as shown in Figure 1 allow the use of relative slow and low cost Phase Lock Loop synthesisers which can be integrated into a single chip radio. The choice of a channel separation of 256 kHz allows the use of integrated low IF radio receiver techniques removing the need for external and expensive IF filters. Finally, the complexity of the digital protocol formats is compatible with low cost and low power digital integrated circuit technology.

## 3 Conclusions

A proposed digital radio protocol has been described which allows for efficient, robust and low cost operation of cordless telephones for use in the 902 to 928 MHz frequency band. This digital radio system supports the use of simple fixed pattern frequency hopping, adaptive frequency hopping and finally frequency diversity for

improved performance in the presence of large amounts of radio interference in this frequency band.

This protocol could also be used and adapted for both other radio applications and for operation in other radio frequency bands such as the 2400 to 2483 MHz ISM frequency band.

BEST AVAILABLE COPY

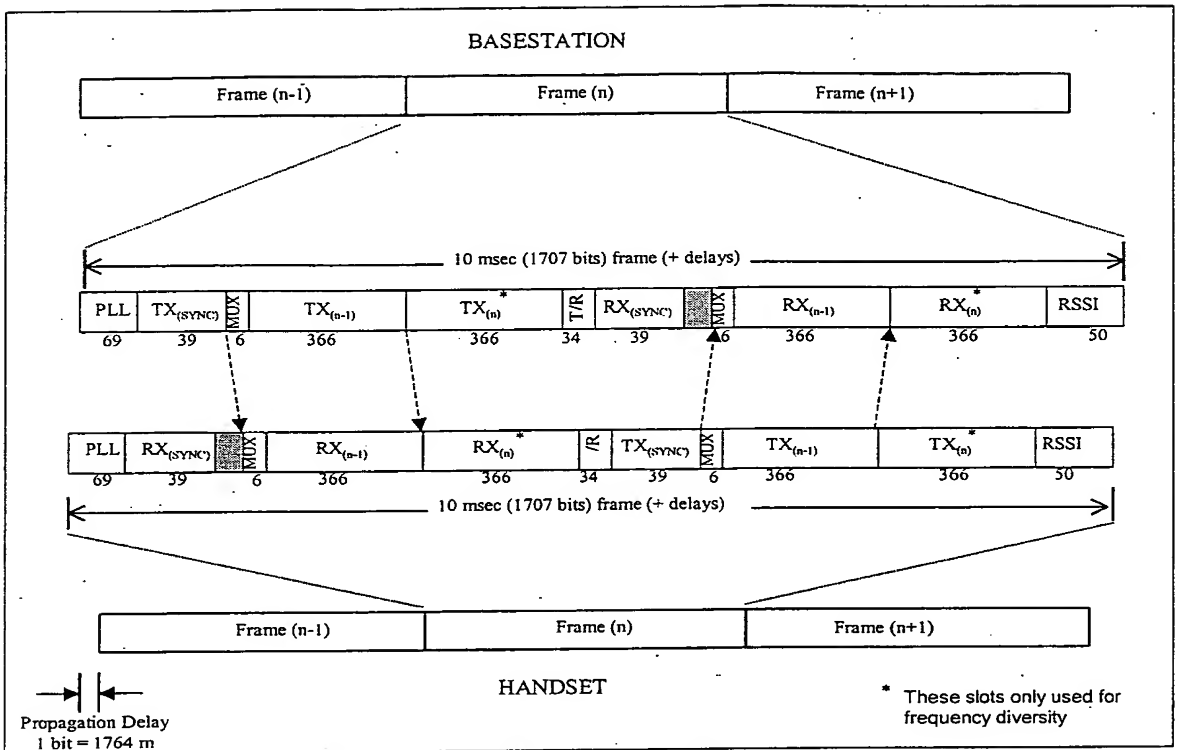


Figure 1: TDD Frame Structure

| MUX format Packet 1 | Data Packet 1 | MUX format Packet 2 | Data Packet 2 | MUX ID |
|---|---|---|---|---|
| AMUX | --- | --- | --- | 00 00 00 |
| DMUX | D | --- | --- | 00 01 01 |
| VMUX | B | --- | --- | 00 10 01 |
| VMUX | B&D | --- | --- | 00 11 00 |
| DMUX | D | DMUX | D | 01 01 11 |
| DMUX | D | VMUX | B | 10 01 11 |
| DMUX | D | VMUX | B&D | 11 01 01 |
| VMUX | B | DMUX | D | 01 10 11 |
| VMUX | B | VMUX | B | 10 10 11 |
| VMUX | B | VMUX | B&D | 11 10 01 |
| VMUX | B&D | DMUX | D | 01 11 10 |
| VMUX | B&D | VMUX | B | 10 11 10 |
| VMUX | B&D | VMUX | B&D | 11 11 00 |

Bit 5 = parity from bits 1 & 2.
Bit 6 = parity from bits 3 & 4.

**Figure 2 : Radio Protocol digital multiplex formats**

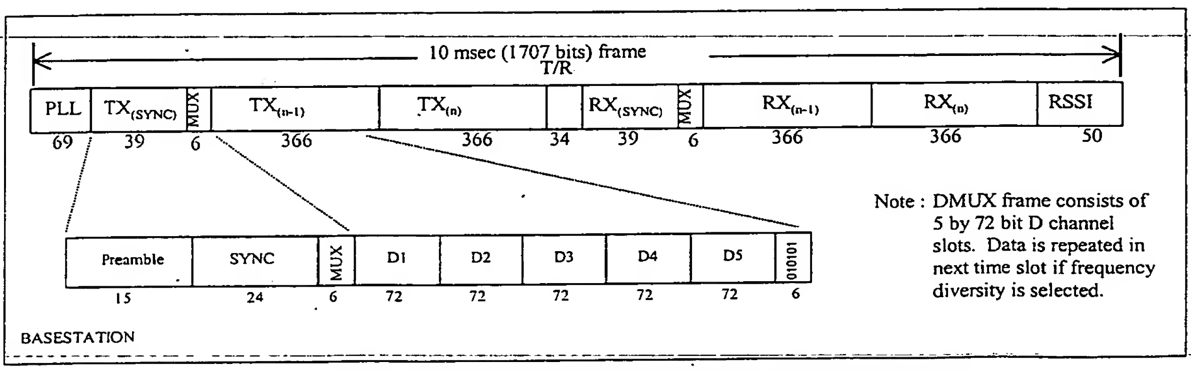


**Figure 3: D MUX Format with Frequency Diversity**

BEST AVAILABLE COPY

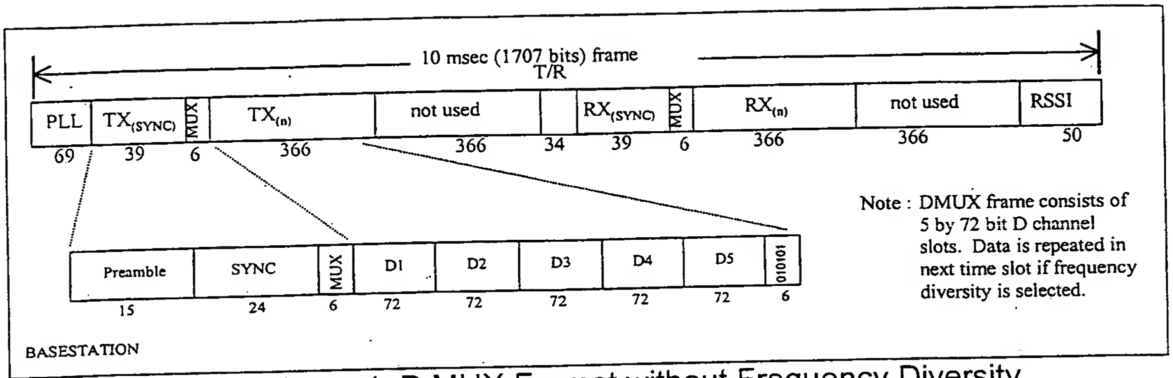


Figure 4: D MUX Format without Frequency Diversity

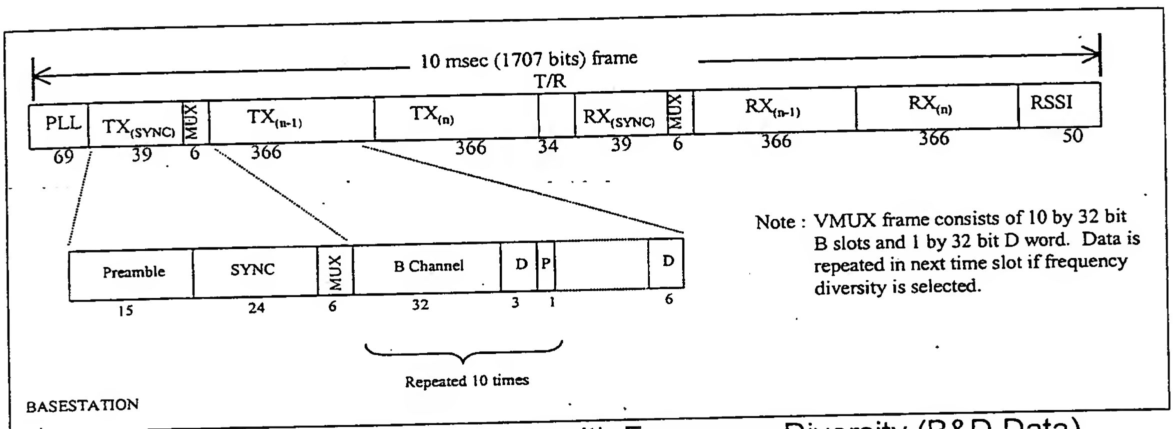


Figure 5: VMUX Format with Frequency Diversity (B&D Data)

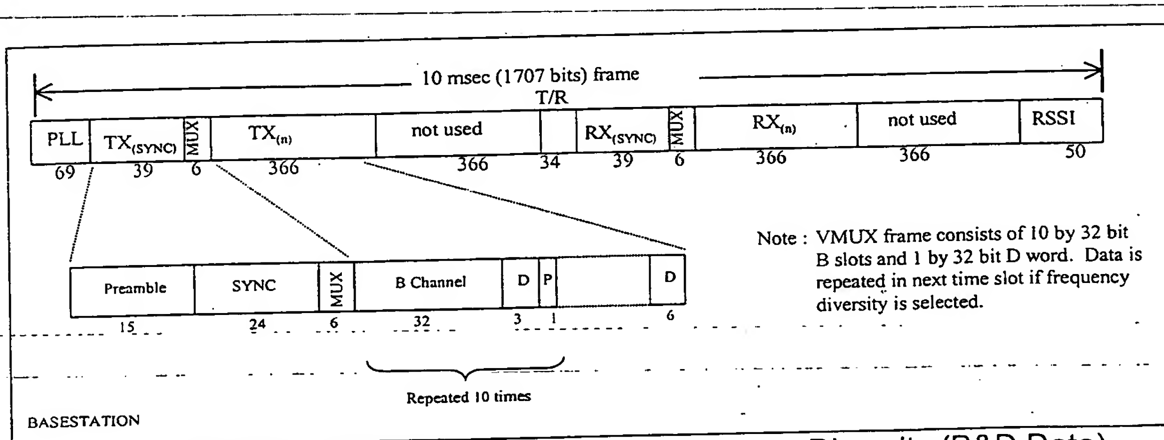


Figure 6: VMUX Format without Frequency Diversity (B&D Data)

BEST AVAILABLE COPY

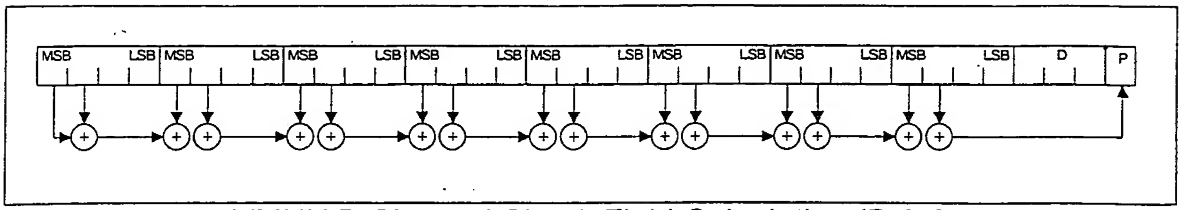


Figure 7: VMUX B Channel Check Field Calculation (B & D channel)

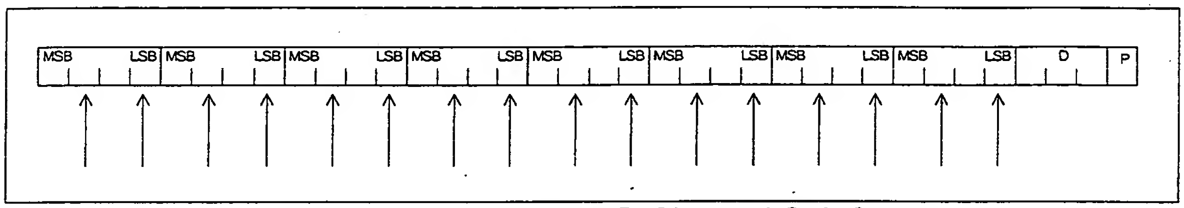


Figure 8: Inverted Bits in B Channel Sub-frame

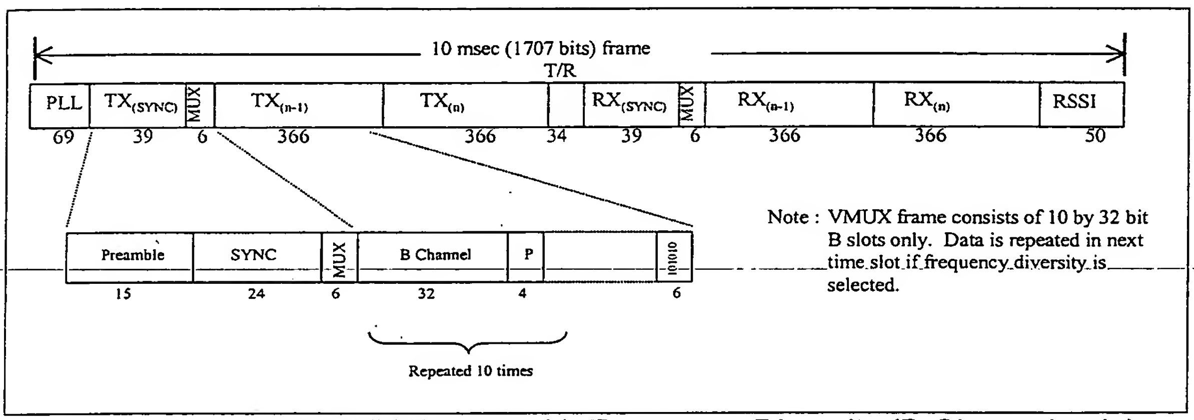


Figure 9: VMUX Format with Frequency Diversity (B Channel only)

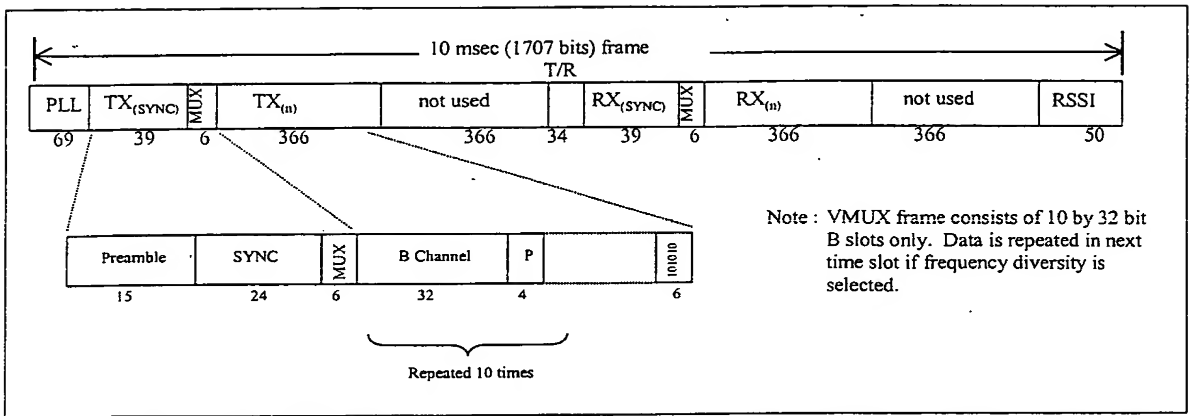


Figure 10: VMUX Format without Frequency Diversity (B Channel only)

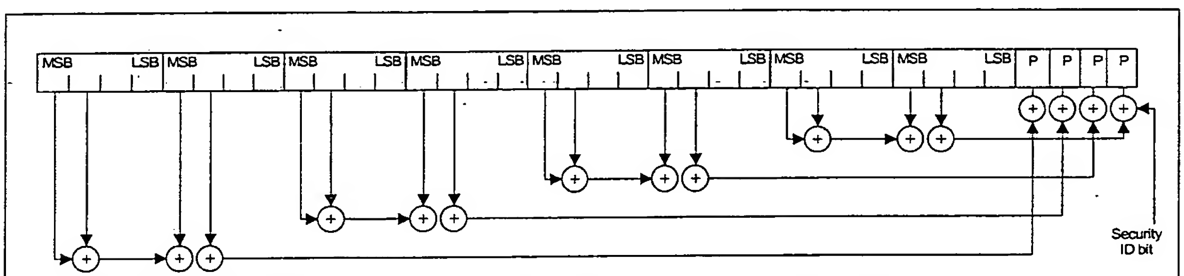


Figure 11: VMUX B Channel Check Field Calculation (B channel only)

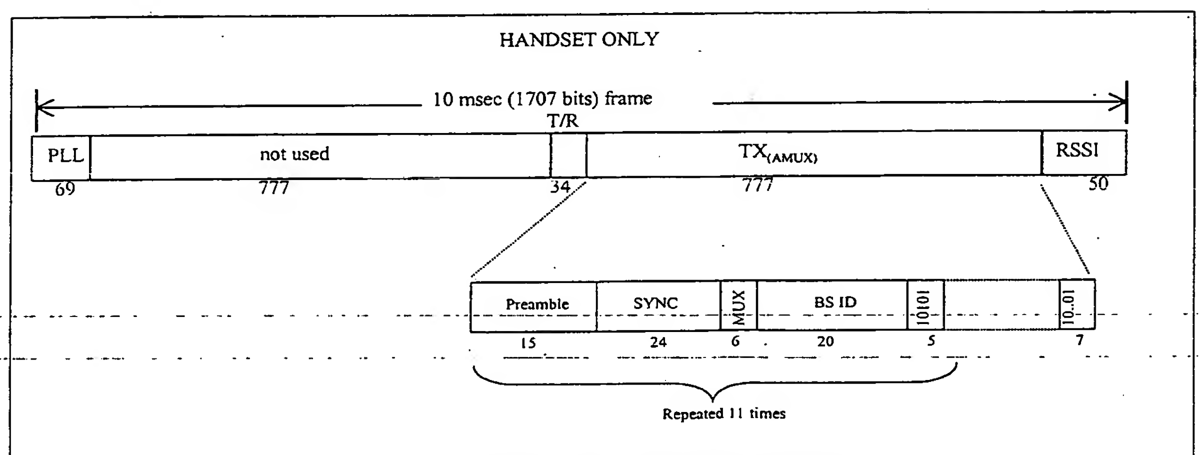


Figure 12 : AMUX Format